1d plume model based on equations in Joe Kordzi's Basic program. The solution is not coupled, but instead individual components are added together. Individual parts include regional groundwater velocity, operational plume, buoyancy, dispersion, and diffusion.

Facility: Corsicana Technologies
Case: 2 - k=191 md 300years

1. Define Units

$cp := .01 \cdot poise$

$g = 9.807\, m \cdot s^{-2}$

$md := 7.32441 \cdot 10^{-8} \cdot \frac{\frac{ft^3 \cdot cp}{sec}}{ft^2 \cdot \frac{psi}{ft}}$

$gal := 0.1336894 \cdot ft^3$

$acre := 43560 \cdot ft^2$

2. Reservoir and 10,000 Year Plume Demonstration Parameters

$\rho go := 61.97 \cdot \frac{lb}{ft^3}$

$\rho gi := 61.61 \cdot \frac{lb}{ft^3}$

$k := 191 \cdot md$ permeability

$\rho gi = 0.987 \frac{gm}{cm^3}$ injectate density

$\phi := 0.20$ porosity

$\rho go = 0.993 \frac{gm}{cm^3}$ formation fluid density

$h := 36 \cdot ft$ net thickness

$cumvolume := 50 \cdot \frac{gal}{min} \cdot 30 \cdot yr$

$dip := 200 \cdot \frac{ft}{2.355 \cdot mi}$ taken from structure map

$\mu := 0.479 \cdot cp$ viscosity

$cumvolume = 7.889 \times 10^8\, gal$ cumulative injection volume

$\Delta t := 300 \cdot yr$ plume drift time

$\theta := 0.92146586\, deg$ $\sin(\theta) = 0.016082$

$\alpha T := 16 \cdot ft$ transverse dispersivity

$D0 := 4.8 \cdot 10^{-5} \cdot \frac{cm^2}{s}$ free water diffusivity

$\alpha L := 160 \cdot ft$ longitudinal dispersity

$CRF := 1 \cdot 10^{-3}$ concentration reduction factor

$Vdrift := 0 \cdot \frac{ft}{yr}$ regional groundwater velocity

$\tau := 1$ tortuosity

3. Operational Plume Radius and Area

$operational\_plume\_radius := \sqrt{\frac{cumvolume}{\pi \cdot \phi \cdot h}}$

operational_plume_radius = 2.123×10^{3} ft calculated operational plume radius

$Area\_of\_plume := \pi \cdot operational\_plume\_radius^{2}$

$Area\_of\_plume = 14153336.4\,ft^{2}$ calculated operational plume area

$Area\_of\_plume = 324.916\,acre$

4. Movement due to Regional Ground Water Velocity

$\Delta t = 300yr$ $Vdrift := 0 \cdot \frac{ft}{yr}$

$Ground\_water\_movement\_distance = Vdrift \cdot \Delta t$

$Ground\_water\_movement\_distance = 0\,ft$ calculated movement from regional velocity

5. Movement due to density drift from bouyancy

$Den1 := 4 \cdot \pi \cdot \sqrt{\alpha T \cdot \alpha L} \cdot k \cdot |\rho gi - \rho go| \cdot g \cdot \sin(\theta) \cdot \Delta t$

$Den1 = 1.032\,kg \cdot s^{-1}\,ft$

$Den2 := \phi^{2} \cdot \mu \cdot Area\_of\_plume$

$Den2 = 88.542\,kg \cdot s^{-1}\,ft$

$Den3 := 4 \cdot \pi \cdot \frac{\sqrt{\alpha T \cdot \alpha L}}{Area\_of\_plume \cdot \phi}$

$Den3 = 2.17 \times 10^{-4}\,ft^{-1}$

$Density\_drift\_distance := \frac{\left[\left[1 + \left(\frac{Den1}{Den2}\right)\right]^{0.5}\right] - 1}{Den3}$

$Density\_drift\_distance = 26.8\,ft$ calculated plume movement from bouyant drift

6. Movement due to dispersion and diffusion

$\tau := 1$ tortuosity $D0 = 4.8 \times 10^{-9}\,m^{2} \cdot s^{-1}$ free water diffusivity

$CRF = 1 \times 10^{-3}$ concentration reduction factor

L := Density_drift_distance + operational_plume_radiu

L = 2149.3ft operational plume radius and buoyant plume length

$standard\_deviation := [2 \cdot [(\alpha L \cdot L) + (D0 \cdot \tau \cdot \Delta t)]]^{0.5}$

standard_deviation= 829.9ft

Iterative Calculations for error function

$i := 0 .. 600$ $X_i := 0.01 + (i \cdot 0.001)$ $X_0 = 0.01$

Error_CRF := 2 · (CRF) Error_CRF = 0.002

$Error\_function_i := erfc(X_i)$ $Error\_function_0 = 0.98871658444415$

$Difference_i := Error\_function_i - Error\_CRF$ $Difference_0 = 0.987$

Converge(X, tol) :=
- j ← 0
- while $Difference_j > tol$
  - j ← j + 1
- X_j

Programming loop to determine argument - solve inverse complementary error function

Define arrays for loop

Converge(X, 0.000000000000)1 = 2.186

Z := Converge(X, 0.0000000000000)

Z = 2.186 The argument of the inverse complementary error function

$\Delta r := \sqrt{2} \cdot Z \cdot standard\_deviatior$ from the following equation: $CRF := erfc\left(\frac{\Delta r}{standard\_deviation \cdot \sqrt{2}}\right)$

Δr = 2565.7ft diffusive and dispersive plume component

7. Summary of Results

operational_plume_radius= 2122.5ft	calculated operational plume radius
Ground_water_movement_distance= 0ft	calculated movement from regional velocity
Density_drift_distance = 26.8ft	calculated plume movement from bouyant drift
Δr = 2565.7ft	diffusive and dispersive plume movement

total_plume_distance := operational_plume_radius + Ground_water_movement_distance + Density_drift_distance

total_plume_distance = 4715ft total plume movement from all effects

↑ radial distance from well the .001 dispersion factor is expected to be after 300 years